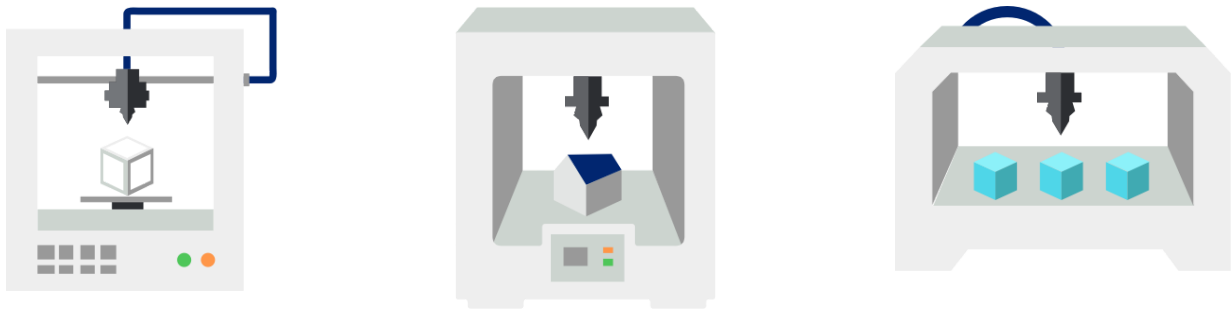


# EXHIBIT

# 34

## HOW TO 3D PRINT

# Beginner's Guide To 3D Printing



The aim of this guide is to teach you the fundamental concepts of how to 3D print, and provide you with the tools and resources you need to get started and make an informed choice about buying your first 3D printer. You will learn the basic history of 3D printing, the software that powers it, how the hardware works, and other crucial information that will help you get started.

This guide will be updated over time with new content, images, and embedded videos.

**W**e were initially going to package this guide up as an ebook and sell it for a small sum, in order to help fund the running of 3D Insider. However, after much deliberation it was decided by the team here that we would rather give this guide away for free – as in 100% free.

This beginner's guide to 3D printing is our way of giving something useful back to the 3D printing community

Now that the house-keeping is out of the way, let's get on with the guide!

## CHAPTERS

# **1** What is 3D Printing?

# **2** Uses of 3D Printing

# **3** Different 3d Printing Processes

# **4** Getting Started – What You Need To Know

# **5** Essential Software

# **6** Essential Hardware



## **How to Choose a 3D Printer**

# **8 Maintaining Your Printer**

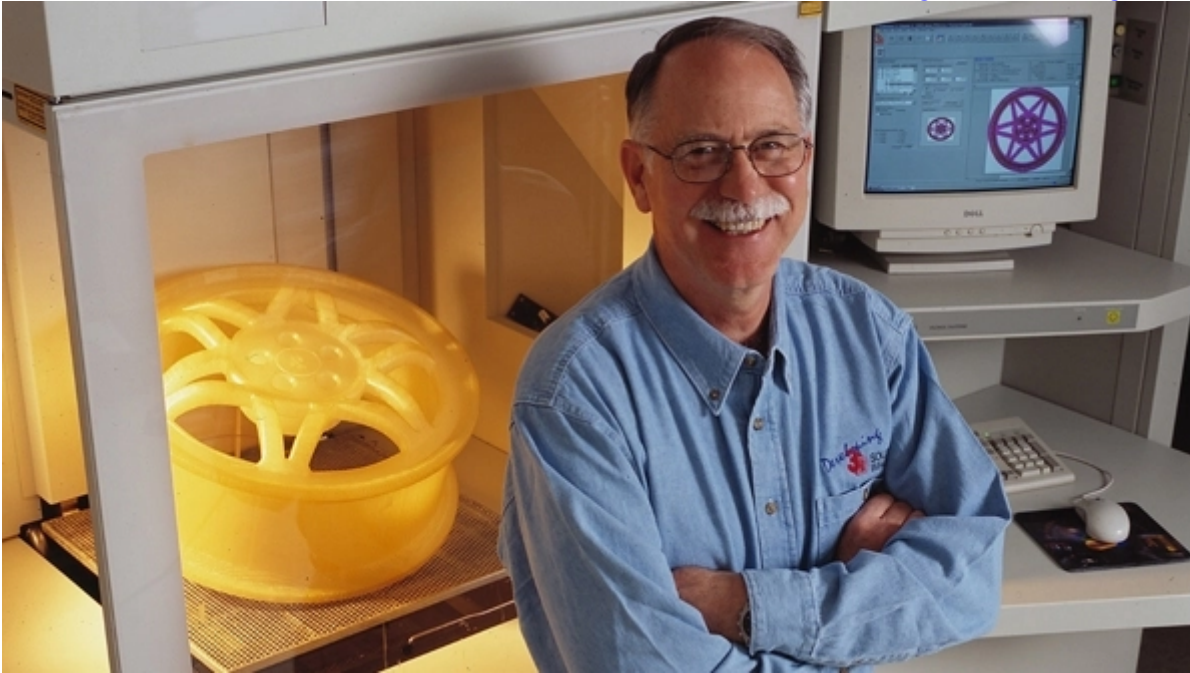
## **1 Chapter 1 What Is 3D Printing?**

3D printing is also known as additive manufacturing, or desktop fabrication. It is a process in which a real, physical object is created based on a 3D design blueprint. 3D printing is an emerging technology that first was introduced in the year 1986; however, it wasn't until the 1990s that it began to draw serious attention from all corners of the technology world.

For many, 3D printing is no less than a technology right out of Star Trek or some parallel universe. The ability to create objects from the ground up is really astonishing for a great number of people.

### **A Brief History of 3D Printing**

It was in 1984 when a process called stereolithography (SLA) was invented by a person named Charles Hull, who later went on to cofound the company 3D Systems. This printing process gave birth to the whole concept of 3D printing, as it enabled the production of a 3D object from a digital design. This allowed the creation of a 3d model from a picture or blueprint, before investments were made in large manufacturing processes by companies.



The very first machine capable of creating 3D objects from computer design was produced by 3D Systems. The machine was named the Stereolithographic Apparatus, as it utilized stereolithography as the process for printing 3D models. Since the development of this machine, rapid developments have occurred in the field of 3D printing.

The vast potential of this technology was realized in the middle and latter stages of the 1990s, when fully-functional organs were produced. The first lab-grown organ was successfully transplanted in young patients who were undergoing urinary bladder augmentation using a 3d-printed synthetic scaffold that was coated with cells from their own body.

This proved that the raw materials for creating objects could range from plastic, to metals, to human cells. The possibilities were endless and the future looked extremely bright for 3D Printing technology. Apart from the SLA process, the onset of selective laser sintering (SLS) in 2006 paved way for mass and on-demand production of industrial parts. In the very same year, a company named Objet introduced a 3D printer that was capable of printing objects using numerous types of raw materials.

The year 2008 saw the first self-replicating printer which was capable of 'producing itself' by printing its own parts and components. This enabled users who had access to such a type of a printer to create more printers for other people, such as friends and family. Later in the same year, major breakthroughs were achieved in prosthetics when a

person successfully walked with a 3D printed prosthetic leg consisting of all parts including the knee, foot and socket created as a part of the same structure without any assembly.

MakerBot Industries, an open source company, started selling DIY kits in 2009 that allowed people to create their own desktop 3D printers. The following years saw a great rise in the number of applications of 3D printing, as the world's first 3D printed aircraft took to the skies above University of Southampton in UK.

## 3D Printing: How It Works

Contrary to traditional subtractive manufacturing processes that rely on methods of cutting and drilling to carve out objects, an additive manufacturing process like 3D printing works by 'fusing together' layers of powdered material to build an object.

This task is performed by a machine called a 3D printer which, under computer control, can carry out this process with unmatched precision and superior accuracy.

A typical modern 3D printer that creates objects based on the SLS process primarily works in the following manner. Here are some of the components and raw materials to give you an idea of how 3D printing works:

1

### LASER SOURCE

A laser is directed from the laser source to solidify and fuse together the molecules of a certain raw material.

2

### ELEVATOR

The Elevator is a component of a 3D printer that raises or lowers the platform to lay the layers of the particular object that is being manufactured. Keep in mind that 3D printers create an object layer-by-layer. Thus, the elevator helps in moving the object accordingly.

3

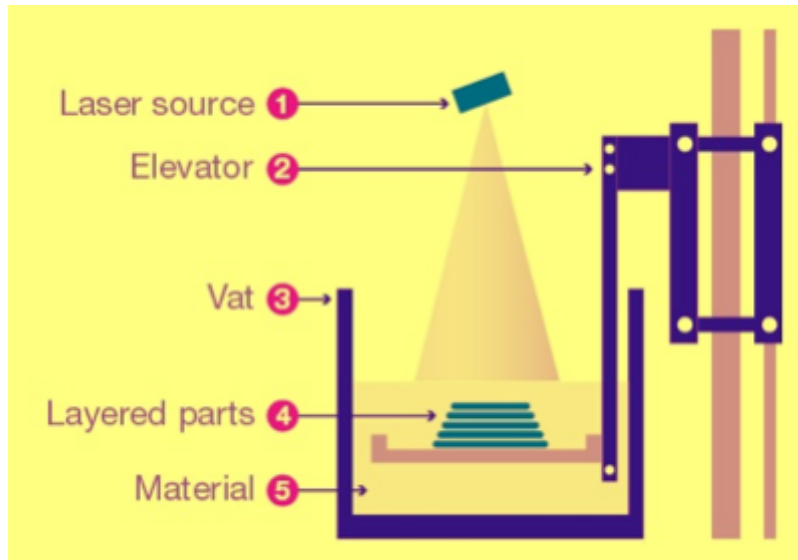
### VAT

Think of the Vat as being a reservoir for the raw material.

4

### MATERIALS

Today's advanced 3D printers are capable of using one or more types of raw materials for creating objects. The materials that they can use include plastic, metals, resin and polymers.



## Applications Of 3D Printing

The rapid growth and improvements in 3D printing technology have enabled many industries to benefit from it. Here are some of the industries that use 3D printing for a variety of purposes:

### AEROSPACE

The technology is being used to manufacture complex yet lightweight parts for aircraft and space applications.

### ARCHITECTURE

This industry utilizes this technology for structure verification, design review, reverse-structure engineering, and expedited scaled modeling

### **AUTOMOTIVE**

The automotive industry actively uses 3D printing technology for design verification as well as for the development of new engines.

### **DEFENSE**

3D printing technology in the Defense sector is being utilized for making light-weight parts for surveillance equipment

### **EDUCATION**

3D printing provides an excellent method for geometry visualizations and design initiatives at art schools. It is also used in numerous disciplines of study for research purposes.

## **ENTERTAINMENT**

All kinds of prototypes of toys, action figures, games, musical equipment and other things are being manufactured using 3D printers.

## **HEALTHCARE**

The medical field has gained an edge as a result of the advancements in 3D printing. A number of working organs have been created and a lot of research is being carried out. It may not be too long when organs for transplant could be easily 'printed'.

## **MANUFACTURING**

The manufacturing industry employs the use of 3D printing for a variety of purposes, including creating models of products before they are manufactured on a mass scale. It is also used to achieve a faster product development cycle and for design troubleshooting.

This excellent video by Stratasys will help you understand further the applications of 3D printing:

## The Stratasys Fortus 380mc & 450mc FDM 3D Printers



## 2 Chapter 2 Uses of 3D Printing?

Similar to the ways in which computing was considered to be the hotbed of innovation in the early 1970s, 3D printing is also experiencing an analogous renaissance. 3D printing technology in its early days was limited to industries that could afford the highly expensive 3D printers. However, as the costs began to lower as a result of the developments in the technology, desktop 3D printers have granted access to hobbyists and anyone willing to try out the new technology.

As previously discussed, 3D printing is being used for a number of applications across a many fields, and is also being used extensively for educational purposes. What is it that makes this emerging technology important?

### Fundamental Change to Manufacturing Processes

When it comes to the current commercial manufacturing process, assembly lines are utilized to assemble various parts together until the final product takes shape. 3D Printing will have huge implications for the current manufacturing processes.

For example, the use of a 3D printer for manufacturing products at a factory will only require a computer design to be sent to the printer, thus eliminating the need of assembly lines, as the printer will be able to churn out complete products.

As previously mentioned, 3D printing technology falls within the boundaries of additive manufacturing, which is the opposite of subtractive manufacturing processes where objects are 'carved out' using numerous tools. The former, on the other hand, builds the

object layer-by-layer without the use of any particular tools. This enables designers to devise even the most complex of designs without having to worry about how they will actually be created; 3D printers can generally print out complex designs with no problems at all.

3D printing is still in its early stages, and it will take some time for it to develop into something similar to that of the 'replicators' found in the sci-fi series Star Trek. Nonetheless, it has been developing at an exponential rate, and it continues to offer compelling benefits. 3D printing is capable of producing objects with complex internal structures, which would otherwise be almost impossible with traditional methods of construction. Take the example of an adjustable wrench; using traditional manufacturing processes, a number of actions including forging, grinding, milling and the assembly are required just to create an adjustable wrench. On the other hand, 3D printing can create this wrench in a single process.

## **Fundamental Change to Manufacturing Processes**

3D printing has the potential to be greener than traditional methods of manufacturing. 3D printers can be used is for fixing old items, such as cars that have become obsolete (and the manufacturer no longer supplies or creates the spare parts). Due to the unavailability of spare parts for old cars, they are usually recycled or left to be dumped into landfills, thus harming the environment.

Some people have been using 3D printers to create obsolete parts in order to keep their cars running. The same idea can apply on almost any other product out there that can be revived using parts from a 3D printer. The possibilities are truly endless. Even something as simple as a battery cover for a remote control can be created, reducing the need to throw the old remote away.

## **Localizing Production of Items**

3D printing can also be used to localize production of items, resulting in a massive change to supply chains and logistics. Rather than supplying from a single factory outlet, a company will be able to establish much smaller production units all over the areas which they serve, thus minimizing transportation costs. This will be a great advantage to multinational companies that serve at a global level. Smaller batches could be created at strategically-placed locations to effectively cover all the countries while reducing the logistical expenses significantly.

The increased efficiency offered by 3D printing will also pave way for greater customization for consumers. Also, instead of outsourcing, the local production of items will bring back manufacturing to domestic soil. Although such complex economic discussions are beyond the humble authors of this book, we think that the potential for a true “renaissance” of manufacturing in countries such as the United States and United Kingdom is immense ... and all thanks to 3D printing.

Before the 3D printing technology can bring about significant changes to the manufacturing industry, it first has to establish itself as being ready for mass, mainstream manufacturing; with the rates at which the technology is improving, the day may not be far when instead of buying products, people buy design blueprints and print the products using their desktop 3D printers!

## 3 Chapter 3 Different 3d Printing Processes

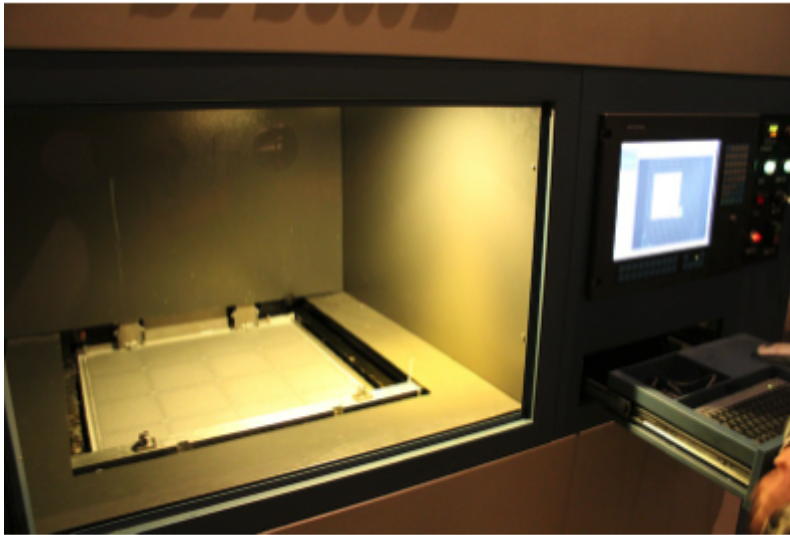
The term 3D printing technically refers to the development of any object from the ground up. This offset of additive manufacturing makes use of different processes to help accomplish this job. Regardless of the process used, the idea behind the creation of objects using 3D printing technology remains the same; starting from the production of a 3D model using computer-aided design (CAD) software to the setting up of the machine. However, the actual process used to create the physical object varies.

There are four different types of 3D printing processes that you are likely to encounter, and they are as follows:

- Stereolithography (SLA)
- Selective Laser Sintering (SLS)
- Fused Deposition Modeling (FDM)
- Multi-Jet Modeling (MJM)

### Stereolithography (SLA)

The 3D printing process called stereolithography is generally considered to be the pioneer of all other 3D printing processes. Charles W. Hull, the founder of 3D systems, introduced and patented this process in 1988. This process makes use of a vat of liquid photopolymer resin that is cured by a UV laser. The laser solidifies that resin layer by layer , in order to create the whole object.



Higher-end SLA 3D printer working its magic.

## How it Works

An SLA 3D printer starts off with an excess of liquid plastic. Some of this plastic is cured (or hardened) to form a 3D object.

There are four main parts in an SLA printer:

- A printer filled with liquid plastic
- A perforated platform
- A UV laser
- A computer which controls both the laser and the platform

To begin with, a thin layer of the plastic (anywhere between 0.05-0.15mm) is exposed above the platform. The laser 'draws' the pattern of the object over the platform as depicted in the design files. As soon as the laser touches the material, it hardens. This process continues until the whole object has been constructed.

Objects that are created using SLA are generally smooth, while the quality of the object is dependent on the complexity of the SLA machine.

Here's a short video that explains the SLA printing process in greater detail:

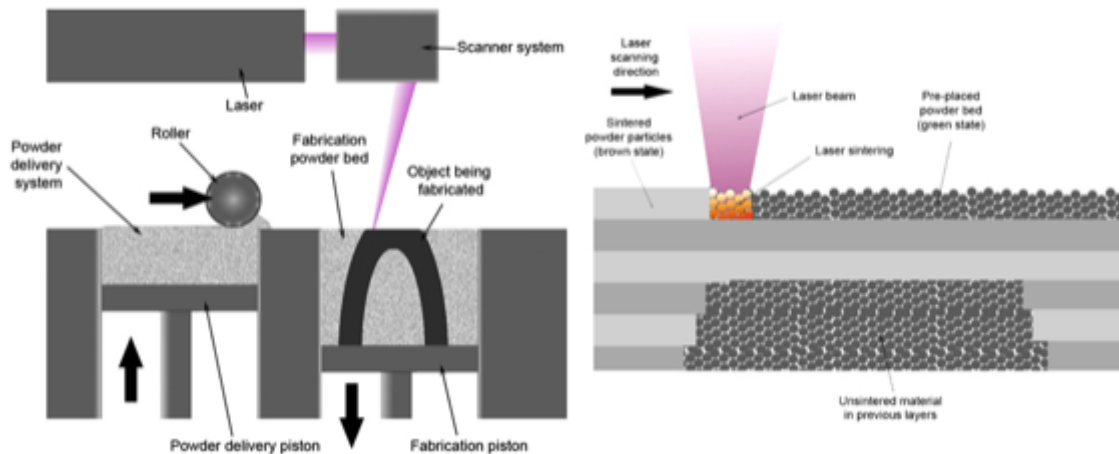
## The Stereolithography (SLA) rapid prototyping proc...



### Selective Laser Sintering (SLS)

SLS is one of the most commonly used 3D printing technologies. During the SLS printing process, tiny particles of ceramic, glass or plastic are fused together by a high-power laser. The heat from the laser fuses together these particles to form 3D objects.

Carl Deckard, an undergraduate student at the University of Texas, along with his Professor, Joe Beaman, developed and patented this process in the 1980s.



The SLS 3D Printing Process

### How it Works

Like all other 3D printing processes, the process of creating an object with an SLS machine begins with designing of a 3D model using CAD software. These files are then converted into .STL format, which is recognizable by 3D printers.

SLS utilizes powder materials, usually plastics like nylon, to print the 3D objects. The laser is controlled by a computer which instructs it to print the appropriate object by tracing a cross-section of the object onto the raw material (powder).

The heat from the laser is equal to, or slightly below, the boiling point of the particles. As soon as the initial layer of the object is formed, the platform of the 3D printer drops by no more than 0.1mm to expose a new layer of the powder. Layer by layer, the object is created and it has to be allowed to cool before being removed from the printer.

This video explains SLS 3D printing in greater detail:

## **Fused Deposition Modeling (FDM)**

The Fused Deposition Modeling printing process is an additive manufacturing technology that is used for the purposes of modeling, prototyping and production applications. This method also works by creating an object layer by layer. However, there are some differences in the way the materials are used by this technology.

## Basic guide to FDM 3D printing

### How it Works

3D printers that utilize the FDM technology construct an object layer by layer; they heat a thermoplastic material to a semi-liquid state. Two materials are used by FDM to complete the printing; a modeling material and a support material. The former constitutes the final product, while the latter acts as scaffolding.

The raw materials are supplied from the printer's bays and the printer head is designed to move based on X and Y coordinates, controlled by the computer. It only moves vertically (Z-axis) when a layer has been completed.

The benefits offered by FDM make it suitable for use in offices, as it is a clean and easy-to-use method.

Solid Concepts Inc. have put together a great video that explains the FDM process in an easy-to-follow fashion:

## Multi-Jet Modeling (MJM)

The principle of working of a 3D printer utilizing multi-jet modeling is starkly similar to that of an ink jet printer. This process is sometimes also referred to as thermojet. It is a type of a rapid prototyping process that can create wax-like plastic models.

### How it Works

MJM printers have a head that has dozens of linear nozzles that sprays a colored glue-like substance onto a layer of resin powder. Due to the fact that this technology does not have the same kind of limitations as SLA, it is able to produce exceptionally detailed objects with thickness as fine as 16-microns. However, they aren't as tough as those created using SLA.

Using this method, the printer is able to create a wax-like 3D object layer by layer.

### Conclusion

All types of 3D printing processes have a few things in common; they all require a 3D model in .STL format in order for the printer to be able to understand the blueprints it has to develop. All types of 3D printers build objects layer by layer; the major difference lies in the technique they use to solidify the raw materials, as well as the nature of the raw materials themselves.

For instance, SLA utilizes a UV laser to cure the material (which is in liquefied form), whereas, SLS uses a laser to solidify the raw material which is in powdered form. Each of the types offers their own set of benefits for numerous types of applications. Some are clean (and simple!) enough to be used in homes and offices, while some are currently

limited to industrial applications. Nonetheless, the rapid advancements in all 3D printing technologies are bringing them within the reach of technology enthusiasts and home users.

## **4** **Chapter 4** Getting Started – What You Need to Know

Getting started with 3D printing can be baffling, to say the very least. With so many new things to learn, newcomers can find it extremely hard to figure out where they should begin (that's why you bought this eBook, right?!) There are many questions that need to be answered before you actually take the plunge and enter the world of 3D printing.

This chapter will focus on answering the common questions that perplex a novice – such as yourself – when they attempt to understand the complexities of the 3D printing technology.

### **Do You Really Need a 3D Printer?**

Desktop 3D printers can now be purchased at affordable rates. The first and foremost question that needs to be answered is whether you really need to get a 3D printer of your own. There are a great number of online resources that can print models and deliver them to you.

So if you only need to get something printed occasionally, then it would be best to simply send a blueprint of the object to one of these services, and avoid all the hassle completely.

### **If You Do, Which Printer Should You Buy?**

Let's be honest here ... you will probably want to buy a 3D printer of your own – it's one of the most exciting purchases you will ever make! You will need to choose between buying a pre-assembled machine, and getting one that you have to build yourself. Both routes come with their own set of advantages and disadvantages. If you're blessed with do-it-yourself skills and a fair bit of technical knowledge, you may find the latter option more appealing. Building your own 3D printer will also cost you less, but it sure isn't for the faint hearted.

One thing to bear in mind with constructing your own kit set 3D printer is that anything goes wrong with the 3D printer down the track, you'll already have the necessary experience to disassemble it and put it back together again.

However, because this is a guide aimed at beginners, the best, and recommended course of action would be to purchase a desktop 3D printer in the first instance. The cost of 3D printers has reduced significantly over the past few years; however, you should still expect to spend around \$1000-1500 to get a decent desktop 3D printer.

On 3D Insider we have a regularly-updated guide to [3D printers for sale](#). This is the best place to start when it comes to looking for your first 3D printer.

You can always contact the 3D Insider team on [3dprinterplans@gmail.com](mailto:3dprinterplans@gmail.com) and we will be more than willing to help you pick your first 3D printer as well.

For your information, we started out with a Solidoodle 3 3D printer. Here's a print we did in action:

The great thing with 3D printing is that the prices of printers are coming down, while at the same time the choice and quality of these same printers is going up.

Before you purchase your own 3D printing we strongly encourage you to get in touch with us at [3dprinterplans @ gmail.com](mailto:3dprinterplans@gmail.com) (remove the spaces) and we can help you make the right purchase.

## Where Can You Get 3D Model Blueprints?

When it comes to the actual design blueprints of the objects, you have two options: you can either get them online ready-to-go, or make your own.

You can find all kinds of models on a website called the Thingiverse. Even though this website is owned by the renowned manufacturers of the Replicator printer, Makerbot, it still contains a decent inventory of blueprints by ordinary users.

If you insist on making your own models (this is the best part!), then proceed to the next question below.

## How Can You Make Your Own Models?

There was a time when Computer Aided Design (CAD) software was designed by engineers, for engineers. This software used to be extremely complex (to an extent it still is complex ... but is more manageable now) and no one except those with the proper

training could use CAD software effectively.

CAD software has a steep learning curve. Times have changed, and the latest in CAD software is aimed at general users. The best thing about modern CAD software is that it is not as difficult to learn and use as it was previously; however, the learning curve is still pretty steep, and you would need to dedicate quite a bit of your time and effort to fully grasp all the concepts of 3D printer-ready design using CAD.

In order to learn the basics of CAD designing software, check out Autodesk's 123D Design and Inventor Fusion. Both of these programs are free for limited licences. You can use the free versions of these software tools to design models for printing.

One thing to bear in mind, however, is that the free/limited/student versions of CAD software do not generally allow you to sell your printed objects, or to sell the files you create. As always, you need to do your own due diligence and investigate the licensing for any software you download.

If you plan on 3d printing as a business, then you really do need to invest in a commercial software licence.

We will talk more about software later in the guide.

## **Can You Simply Scan Real Objects And Print Them?**

A lot of people wonder whether it is possible to 'simply scan and print' objects. It is possible, and there are a few companies that create dedicated 3D scanning equipment, such as Go!SCAN 3D. However, the scanned models generally require a lot of tweaking before they can be used to print objects.

This idea is undoubtedly ingenious, but it will take a little time to mature; at present you are still better to create the files "by hand" and then print them from there.

## **How Should You Go About Printing Downloaded Models?**

If you have downloaded model blueprints from websites like Thingiverse, chances are that they will already be in STL format. This format is halfway to becoming a printable file ... so stay tuned for how to turn that STL file into something seriously awesome.

For the printer to be able to manage the design files, they have to be sliced – which means that it has to be transformed into the exact layer-by-layer description of the object, including the temperature, the speed and wall thickness controls. The resulting file is called a G-Code file that can be interpreted by the printer.

You can choose from a number of slicing applications in the market, including free ones such as ReplicatorG, Cura and KISSlicer. We will talk more about slicing software shortly.

## How Should You Go About Printing Models That You Created?

Slicing software is an important tool required to create a final, printable file. If you used computer-aided design software to create your model, then the software will be able to export it as an STL file. All you would have to do would be to use a slicing software program to transform it into a G Code file.

On the other hand, if you used a 3D program such as Photoshop, Sketchup or any other 3D design program that isn't specifically designed for CAD, then the process of getting the G code file requires several steps.

One of the first things that need to be done is to see whether the 3D model is genuinely printable or not. In most cases, minor changes will be required, such as patching up of holes and repairing of vertices.

Secondly, the file will need to be converted into an STL before it can be sliced for the printer.

You can use a free, open-source application called Meshlab to perform both the tasks of patching up the model and generating the STL file. You may also want to look into a commercial program called NetFabb that can generate the G Code files as well.

## Where Can You Buy the Material?

The printing material (or filament) that is required for the 3D printer comes in two types: PLA and ABS.

PLA is Polylactic Acid, a form of polyester that is made from a variety of natural sources including sugar, corn starch or sugar cane. It is biodegradable and melts at temperatures lower than ABS.

ABS, or Acrylonitrile butadiene styrene is a type of polymer that is oil-based. It is extremely strong and resilient and is commonly used to create children's toys.

You can purchase them in loose forms or as a reel from a wide range of sources. A kilogram of 3.0mm ABS filament reel costs around \$30 on Amazon, which is where we recommend you buy your filament from. Search around to find the best deal and the lowest shipping cost for your location.

## Conclusion

As you can see, it is possible to acquire a 3D printer and the material needed to print within a budget of less than \$2000, provided that you use free CAD software and tools. Nonetheless, cost isn't everything! Before you purchase anything, it is important that you carry out a self-check to see whether you have the willpower and the ability to actually learn 3D printing techniques, because the learning curve is steep.

Take your time to learn the hardware (and software) and have fun along the way!

# 5

## Chapter 5 Essential Software

Without the right software, 3D printing would remain a distant dream. While it is true that you need a specialized printer that can create 3D objects, you also need a variety of essential software that can be used to design the actual model and get it into a format that the printer can recognize.

This chapter will discuss the types of computer software you need, as you begin your journey to becoming a 3D printing expert.

## Introduction To 3D Printing Software

Unless you're planning to download ready-made blueprints of models from the Internet and use them to print objects, you will need to understand what kind of 3D printing software you need. We had discussed this topic briefly in the previous chapter; we will now discuss 3D printing software in more detail.

## The 3D Printing Process

Before we head deeper into discussing 3D printing software, it is a wise idea to briefly discuss the actual 3D printing process from scratch so that you have a clear picture of what exactly you're dealing with.

### Step 1: The Idea

First and foremost: you have to decide what you want to make. It can be anything, from a simple decoration item to a complex toy. It is best if you start with simpler projects until you get comfortable with designing more compound objects. When the team at 3D Insider first got a 3D printer, we experimented with very simple objects (such as cubes)

until our abilities improved. Come up with a number of ideas, and be prepared to reject a number of them from a technical feasibility perspective. It's also important to take action at this stage – it can be very tempting to come up with a number of ideas for the next great 3D printed invention, but never get around to designing and making anything. If you're prone to procrastinating your work, then you might want to read this handy guide that covers the best ways to quit procrastinating – you'll find that you get a lot more 3D printing learning and making done after reading it.

## **Step 2: Design the Model**

Here comes the first main step; designing the actual model. After you have decided what you want to make, you should use CAD software (or non-CAD software) that can help you craft the model. Learning to use any particular design software is no easy task; and you should be well prepared for it as well as being willing to learn.

On the 3D Insider [YouTube channel](#) you'll find some great introductory videos, showing you the ropes of common CAD software – in particular Autodesk Inventor.

## **Step 3: Convert it into STL**

It is absolutely necessary that you convert your model into STL format after it has been completed. Most of the CAD software you'll ever encounter comes with built-in features that allow you to export the model as STL. Nonetheless, if you're planning to use a non-CAD design software, such as Google SketchUp, you will need to install a plugin (Cadspan, in this case) in order to be able to tweak and convert the final design.

After you've converted your model into a STL format, you're only half-way across to getting a 3D printable file.

## **Step 4: Slicing it**

The fourth step requires you to 'slice up' the model into layers so the 3D printer can understand how to go about creating the object. This is the last step involving the use of computer software, after which you will get the final G-code file that the printer can recognize.

To sum it all up: You need software to design the model, convert it into STL and to slice up the model to get it ready for the 3D printer.

## **Computer-Aided Design Software**

Computer-aided design (CAD) software has been around for decades. It was initially designed for engineering applications and was so complex that only engineers with the right training could use them.

Since the inception of 3D printing technology, CAD software has been commonly used to create 3D models of objects. One of the main reasons of using CAD software as compared to non-CAD alternatives such as Photoshop is that it enables the designers to export the model as an STL file.

Just so you remember: An STL file is a format that contains information that is required to produce a 3D model on stereolithography printers.

Due to its complex features, CAD software is rather expensive for commercial use, ranging from \$10,000 up to \$100,000 for the best applications out there. This would be, of course, impractical and unaffordable for a home user who is just entering the world of 3D printing.

Fortunately, a lot of free CAD software has been made available, and is almost as good as some of the paid versions out there. Many commercial CAD programs also have free/limited licence versions which allow you to dip your toes in the world of CAD design and 3D printing without spending thousands of dollars.

Regardless of whether it is free or paid, keep in mind that there is a steep learning curve to grasp the basics of CAD software. You will need to put in a lot of effort and time and will also have to exhibit patience before you can master the art of designing using CAD software.

When it comes to 3D printing, you aren't going to get far before the name "AutoDesk Inventor" is bandied about:

## **AutoDesk Inventor**

Autodesk is a big name in the CAD application industry, and provide professional-level paid software. Autodesk Inventor is a powerful CAD application that comes with a wide range of tools for digital prototyping.

This high-end 3D design application can help to build better products faster and thus reduce the development costs. Due to the fact that it is full-fledged, professional CAD software, you will need to spend a considerable amount of time to learn how it works before you can begin to design your models. There is ample documentation available which will help you through this process.

The latest model by Autodesk is Inventor 2015. A trial version can be downloaded before you actually purchase it. You will need a powerful computer with at least 3GHz clock speed for single-core processors or 2GHz for dual core ones. A minimum of 8GB RAM is required; however, for optimal performance, Autodesk recommends 12GB RAM.

These system requirements are intended for heavy designing applications. As a beginner to the world of 3D modeling, you will not be involved in very complex designs and you may be able to run the software on a computer with slightly lower specifications. Download a trial version to see how it works for you. As of April 2014, the DVD and full licence of Autodesk Inventor 2015 is priced at around \$5000.

If you're looking to get started with AutoDesk Inventor then [check out our "how to" videos](#).

## Autodesk 123D

**UPDATE: Autodesk 123D is no longer available.**

Not all products by Autodesk are paid. Autodesk 123D products include free, yet powerful set of tools for designing 3D models and for getting them in the right format for 3D printing. This suite of hobbyist CAD and 3D modeling tools is based on Autodesk's premium Inventor CAD software and comes built-in with STL support.

While not all applications may be useful for you, the suite contains the following concoction of programs:

- **123D Catch:** This application can create 3D models from a collection of pictures that have been taken at various angles using the concept of photogrammetry.
- **123D Sculpt:** Allows you to manipulate virtual clay into a particular model. This is designed to be used on an iPad
- **123D Make:** Enables creation of LOM-Style solid models.
- **123D Design:** This is the program that you should be most interested in – a simpler version of a CAD design application that can create 3D models.

## Google SketchUp Make

Google SketchUp Make is a completely free and easy-to-learn alternate to the complex CAD software out there. It comes with a few simple tools that allow users to create 3D models of houses, decks, home additions and a lot of other things. This is a great tool for those who are new to the world of 3D modeling as it will offer them a user-friendly way of getting to know the complexities of 3D modeling

It is generally used to design objects for Google Maps and Google Earth; however, a lot of people use it to create models for printing. Google SketchUp isn't a full-fledged CAD software and it does not allow exporting an object as an STL file by default; however, there are plugins available such as Cadspar, that can help you add the final finishing touches to your Google SketchUp model before it is exported as an STL file.

If you're serious about using Google SketchUp then you are better off with SketchUp Pro. This software isn't too badly priced at under \$600 – and you can [get a free trial here](#).

## Slicing and Printer-Control Software

The model that you design go through two further processes on their way to becoming a finished product, and these two processes are called slicing and sending.

Slicing divides the model into several printable layers and plots the toolpaths for them. The control software then sends these 'instructions' to the printer which then creates an object layer by layer.

3D printers are generally controlled through an onboard control screen, or by a computer through a USB connection. This user interface enables the control software (which can be the slicer software itself) to send the computer code (instructions) to the printer and controls the major parameters such as the speed, flow and the temperature required for each layer.

The Netfabb engine, for example, combines the functionality of both a slicer and control software. That been said, there are pure slicers, pure control software or a combination of both.

## Slic3r

Slic3r is an extremely popular tool that has powerful features to convert a digital 3D model into printing instructions for a 3D printer. It is capable of slicing the model into layers and generating the necessary toolpaths as well as calculating the material that needs to be extruded.

The project was launched in 2011 from scratch and has grown to become an application that is supported by almost all of the major 3D printing companies in the whole world.

Due to the fact that Slic3r is just a slicer application, it requires additional software to act as a control application. It comes bundled with the following applications:

- Pronterface
- Repetier-Host
- ReplicatorG

A comprehensive manual can be found at <http://manual.slic3r.org/> for those who are new to the world of 3D printing.

At 3D Insider we have had plenty of experience with Slic3r and its bundled applications – you can always contact us on 3dprinterplans @ gmail.com with any questions you might have.

## **Skeinforge**

Skeinforge is another slicer program that is designed to be used with RapMan and numerous other Fab lab engines. Users can set a number of parameters using this program; this increased functionality makes the learning curve a bit steep and as a new user, you may be better off with simpler tools.

## **KISSlicer**

KISSlicer is a fast and easy to use application that can generate the G Code for a printer from a STL file. The free version of KISSlicer contains all the features that may be required by a hobbyist using a single-head 3D printer. If you require multi-head and multi-model printing, then you may need to opt for the PRO version.

## Conclusion

Whichever design application you settle for, remember that you will have to learn quite a few things and the learning curve is pretty steep even for the simplest of programs. You will need a lot of determination and hard work, especially if you're new to 3D designing altogether. Most of the applications generally come bundled with comprehensive documentation that you should read to grasp the basic functions and layout of the controls.

It is best to start off with free software and only invest in paid ones after you feel that you can handle 3D designing and printing.

# 6

## Chapter 6 Essential Hardware

A thorough knowledge of the hardware of a 3D printer is essential if you want to make the most of this exciting new technology. Both the hardware and the software work you deploy work in conjunction ... so having insufficient knowledge of the hardware means you're missing half the equation!

It can be quite difficult to fully understand the hardware of 3D printers; however, the purpose of the main components is not as difficult to comprehend as it may seem initially. This chapter will briefly discuss how a 3D printer works, and will go on to reveal the major components that make up a basic 3D printer.

## How A 3D Printer Works

By now you should know that a 3D printer creates objects by adding material layer by layer until the object is completed. A printer consists of a frame and features three axes:

- X-axis (left to right movement)
- Y-axis (front to back movement)
- Z-axis (up and down movement)

A part called an extruder is installed on the X-axis and its function is to feed the material that is used to create an object. The lowest part of the extruder itself is called the extruder head – this is the part where the filament is melted and 'extruded' from a tiny hole that has a diameter of no more than a millimeter.

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## The Anatomy of a 3D Printer

You don’t necessarily have to learn about each and every individual part of a 3D printer in order to use it. However, learning about the basic hardware and construction of one can help you if you ever have to troubleshoot a problem (and trust us ... you will have to fix your 3D printer, sooner rather than later!) This knowledge will also be of a great help when you go out to actually buy a printer.

There are various types and methods employed by 3D printers to create objects and we have already discussed them in the previous chapters of this book. In this chapter, our emphasis will be on Fused Deposition Modeling technique that is the most common among desktop 3D printers used at home. This method can be considered to be the same as the ‘glue-gun’ method. The glue-gun method consists of heating up a filament to a point where it melts – this melting filament is then placed in thin layers and the object is created layer-by-layer.

## Print Bed

The print bed is the area where the objects are created layer by layer by the printer. Based on the type of filament you are using, the print bed itself may be heated. You can cover a non-heated bed in painter’s tape.

As for heated print beds, it is important to keep the print bed warm during the whole layering process in order to prevent warping. Temperatures between 40 degrees to 110 degrees Celsius are maintained during the entire printing process.

There are some printers that can reach extremely hot temperatures, and extra care should be taken if there are children around. You’ll quickly learn not to touch a warmed-up print bed!

## Extruder

The extruder is often considered to be the component from where the plastic filament extrudes. However, this isn’t entirely true; the extruder is a part that is responsible for pulling and feeding the filament to a part called the hot end.

A depiction of the various parts of a hot endTypically, extruders are integrated within hot ends. In other cases, they may be located away from the hot end from where they push the filament to the hot end through a tube called the Bowden Cable. A printer with a dual extruder can print using two different colors and materials at the same time. This does come at an extra cost because an extra extruder and a hot end is required.

## Hot End

The Hot End in a 3D printer comprises of a heater, a temperature sensor and an extrusion tip through which the filament is fed. Just as their name implies, they can get extremely hot and should never be handled directly (we mean this ... don't fiddle around with the hot end if you value your fingers!) There are holes in the nozzle that range in size: between 0.2 mm and 0.8 mm.

The smaller the nozzle of the hot end, the finer the print will be; however, the time taken to print the object will also be greater.

## Plastic Filament

While the plastic filament is not a component of the printer itself, it is a consumable that is vital for its operation. Just as you couldn't print on an inkjet without cartridges, you'll be stuffed without your 3D printer filament. There a quite a few types of filaments available for use by 3D printers. The choice is generally limited to two major types when it comes to home 3D printers: ABS and PLA. We will talk about the two types in detail later on in the chapter.

## Different Types of Beginner-Friendly Printers

In this section, we will discuss the advantages and disadvantages of each type of 3D printer, along with some other useful information that will help you decide the kind of printer you should choose.

If you will recall, the three types of printers are:

- Fused Deposition Modeling (FDM) Printers
- Stereolithography (SLA) Printers
- Laser Sintering (SLS) Printers

## Fused Deposition Modeling (FDM) Printers

Fused Deposition Modeling is probably the most common type of additive manufacturing process, and is used by the majority of desktop 3D printers that you are likely to encounter. Filament is fed into the extruder of FDM printers, where it is heated to a temperature high enough to melt it. This melted filament is then extrudes from the nozzles to create an object each layer at a time.

### **Advantages of FDM Printers:**

- Comparatively, these 3D printers are the cheapest and can be bought between \$1000 and \$5000.
- The filament used by these printers is also affordable.
- They can use a large variety of materials.
- They can be easily maintained and parts can also be replaced conveniently.
- They can print objects quite fast.

### **Disadvantages of FDM Printers:**

- The nozzles can frequently clog
- The supports can be problematic to clean up
- The individual layers can be visible in the end product (striping)

The following materials can be used to create objects using an FDM Printer:

- PLA Plastic
- ABS Plastic
- Wood Filament

## **Stereolithography (SLA) Printers**

Stereolithography is probably the oldest additive manufacturing process. These 3D printers contain a pool of liquid resin which is hardened by a beam of ultra-violet (UV) light. As soon as a layer has been formed, the base moves to allow for the creation of another layer, and thus the process continues until the whole object has been created.

This 3D printing method is ideal for those who want great detail in their final products. The cost of these printers can vary between \$3000 and \$7000.

### **Advantages of SLA Printers:**

- The final products can contain great detail down to 25 microns (this is thinner than a sheet of paper).

- The surface of the objects created using this method is smooth.
- This technique is great for casting and molding as well as for creating models.

### **Disadvantages of SLA Printers:**

- The nozzles can frequently clog
- The use of liquid resin can be quite messy
- The materials that can be used are limited.
- The materials used are more brittle.
- These printers are generally more expensive than FDM printers.
- SLA printers can only use liquid resin.

## **Selective Laser Sintering (SLS) Printers**

The Selective Laser Sintering technique works in remarkably similar ways to that of SLA; however, a powder is used instead of a liquid resin. A laser is used to heat up the powder. Once the object has been created, the rest of the powder can be removed leaving only the solid object.

These printers are currently extremely expensive, and cost over \$50,000. Clearly, this is not going to be a viable choice unless you have just won the lottery! Nonetheless, if you wish to have a model printed using this method, you can use numerous online printing services.

### **Advantages of SLS Printers:**

- They can provide detail down to 16 microns.
- No support structures are required for the object being printed.
- Working mechanical parts can be created without a requirement for any assembly.

### **Disadvantages of SLS Printers:**

- It takes a little effort to remove the powder after an object has been printed.
- Currently there are no desktop models of SLS printers.

The following materials can be used to create objects using an SLS Printer:

- Aluminum
- Nylon Plastic
- Sandstone

- Silver
- Steel

## Filament Types – PLA vs. ABS

There are a number of different materials available for use in 3D printers, ranging from numerous metals, wood, plastic to ... wait for it ... chocolate! Yet, when it comes to plastic filaments, the two most common types of plastic filaments are PLA and ABS.

**PLA, or Polylactic Acid**, is a type of biodegradable plastic with many features that make it desirable for 3D printing. For example, it does not give-off any fumes, nor does it warp as much as ABS does. When it comes to the appearance, it is also quite shiny and products made out of PLA have a sleek appearance. It is harder than ABS, yet more brittle. This does not at all mean that it will break easily – on the contrary, PLA is actually extremely strong, and it is far more likely to snap rather than bend as a result of any deformation.

**ABS, or Acrylonitrile Butadiene Styrene**, is a plastic made from petroleum-based sources. It has a melting point much higher than PLA. It is quite strong and is often used to create toys such as Lego. Compared to PLA, objects made from this filament are more likely to bend than snap.

This section will discuss in detail the similarities between these two filament types, as well as the major differences between them. We will also go on to talk about difference in filament thickness. The advantages and disadvantages of each filament will also be described to help you choose the ideal material for your projects.

## The Common Ground

ABS and PLA are both known as thermoplastics. Whenever they are heated, they become soft and can be molded, returning to solid when cooled. This process can be carried out repeatedly, and these properties are precisely what has made them so popular.

There are a great number of thermoplastics available; only a very few are used for 3D printing purposes. In order for a material to be viable for use in 3D printing, it has to pass three tests:

- Initial Extrusion into Plastic Filament
- Second Extrusion and Trace-binding during 3D Printing
- End Use Application

In order to be able to pass the three tests, a material must be first easily formed into a raw 3D printer feedstock called the plastic filament. These filaments come in a reel.

Secondly, the material should be able to form accurate parts of the products being created using 3D printers.

Last but not least, the properties of the plastic must have desirable characteristics related to its strength, gloss, durability as well as numerous other qualities.

ABS and PLA, as well as numerous other thermoplastics can pass the first test in a breeze. It's just a question of the cost and the time required to turn the base plastic resin into a high quality plastic filament.

## Storage

Thermoplastics such as ABS and PLA work best if, before being used (or when being stored for an extended period of time), they are sealed to prevent them from absorbing moisture from the air.

However, this does not imply that the filament will necessarily be spoiled if you let the reel of your filament sit around for a week or so before you use it. Still, extended exposure to the atmosphere can have detrimental effects on the quality of the material as well as the end product.

The filament comes wrapped up in plastic to prevent absorption of moisture. Here is a comparison of the effects of storing ABS and PLA:

**ABS** – If ABS is exposed to the atmosphere and it absorbs unacceptable amounts of moisture, then it will tend to bubble and gush from the nozzle tip when being used to print an object. This will lead to a reduced visual quality, accuracy, strength and will be more likely to clog the nozzle. By using a source of heat such as a food dehydrator, you can easily dry ABS prior to use.

**PLA** – PLA reacts in different ways when exposed to moisture. In addition to forming bubbles and gushing from the nozzle during printing process, a slight discoloration and numerous other changes in its properties will also be seen.

At high temperatures, PLA is known to react with water and this can lead to depolymerization. Depolymerization is a process in which a material undergoes decomposition into simpler compounds.

You can also dry PLA using a food dehydrator, but keep in mind that this can lead to a change in the crystallinity ratio of the material and will probably alter extrusion characteristics. Nonetheless, this isn't a major problem for most of the 3D printers out there.

## Smell

**ABS** – When ABS is heated, a notable odor of hot plastic is pretty evident. For some, this is nothing more than a nuisance, while there are some people who do not even notice it. Regardless of whether you notice the smell or not, it is imperative that you ensure proper ventilation of the room where ABS is being used. Also, make sure that the ABS you use is free of contaminants. A reliable extruder also plays an important role as heating the material to the proper temperature goes a long way in controlling the smell.

**PLA** – Due to the fact that PLA is made from sugar, it gives off a semi-sweet odor equal to that of cooking oil when heated. It definitely won't bring back memories of those delicious home-cooked meals; however, some consider its odour to be better than that given off by ABS.

## Part Accuracy

ABS and PLA both have characteristics that allow them to create dimensionally-accurate parts and products. Still, the following points are worth mentioning when it comes to discussing accuracy of parts.

**ABS** – One of the major challenges involving use of ABS is the upward curling of the surface that is in direct contact with your printer's print bed. By heating up the print bed and by making sure that the bed is clean, flat and smooth, you can really help to eliminate this issue. Some people find it better to apply a number of solutions including ABS/Acetone mixture or simple hair spray onto the print surface prior to printing. At 3D Insider we have experimented with hair spray on the print bed with some success (just remember that hair spray is highly flammable!)

Certain features such as sharp corners usually end up being round. A small fan can be used to cool the area around the nozzle to improve such corners; however, excessive cooling can lead to a reduction in the adhesion between the layers, and may eventually cause the final product to crack.

PLA – PLA warps less than ABS. This is exactly why it can be used to print objects without the need of a heated bed. If cooled actively, PLA can be used to create sharper details including sharp corners without the material cracking or warping. The increased airflow can also assist by strengthening the object by binding the layers strongly together.

## General Material Properties

Regardless of how accurate a certain part is made, it must be able to perform its intended functions.

ABS – ABS can take numerous forms and can also be engineered to have various properties. In essence, it is a strong plastic with moderate flexibility. Before colors are added to ABS, it milky-beige. The mild flexibility of the material makes it easy for it to be sanded and machined. Also, it is much easier to recycle as compared to PLA.

Engineers usually prefer ABS due to its high strength, flexibility and machinability.

PLA – The origin of PLA includes sugar-beets, corn and potatoes. This is why PLA is thought of as being more environmental friendly than ABS. It is commonly used to package food and to make containers foodstuff. In its original form, it is transparent but can be colored to varying degrees of opacity and translucency.

It is much stronger than ABS as well as rigid. Objects printed using PLA carry a glossy look and are smooth to the touch. Nonetheless, it is slightly more complicated to work with due to its complex interlocking assembly and pin-joints.

### Thickness of the Filament

ABS and PLA filaments come in two different diameters: 1.75 mm and 3 mm

Each printer (each extruder, to be more precise), is designed to work with a certain thickness of filament. You will have to see the specifications of your printer to see which filament you can use with your particular model of 3D printer.

Some printers are designed to use proprietary diameters that may be slightly different from the standard thickness. If you haven't bought a printer yet, then you can choose a printer that supports the standard diameters so that you will have more options when it comes to choosing a plastic filament supplier (more options in terms of color, material, etc).

The diameters of the filaments may vary slightly from one manufacturer to another. However, if a filament is labeled as 3 mm, then it must not exceed that value; it can, however, be slightly less than 3 mm (say, 2.88 mm).

Some filament can also have lumps and neck downs in them that run for a few centimeters. Lumps are those sections where the diameter exceeds the rating. On the other hand, neck-downs are those regions where the diameter is less than what it's supposed to be. Jamming and stripping can result from this; nonetheless, such instances are rare, especially if the filament being used has been manufactured by a reliable company. It's generally advisable to avoid "dirt cheap" filament for this reason.

## Conclusion

You should carefully weigh the advantages and disadvantages of each of the materials before you settle for one. Think about what kind of objects you need to print, and what kind of applications they are required to fulfil.

Some say PLA is the best material for beginners to start with, and you may want to try it out to see whether that's true. However, we started with ABS and did not find it overly difficult! You can always switch materials down the lane.

# 7

## Chapter 7 How to Choose A 3D Printer

Gone are the days when 3D printing was limited to prototyping only. Today, 3D printing technology has grown to become quite popular, and continues to do so as the technology improves at consistent rates. It is now capable enough to offer advantages from the initial concept design to the production of the final end product.

If we look just a few years back, the luxury of in-house printing was only limited to a few professional design engineers, while the technology was itself in its emerging stage and limited to a very few design models and prototypes.

The day has come where a great number of hobbyists and creative minds have gotten access to their very own personal 3D printers, empowering them to unleash their creativity to the world. Now people can design their own models and print them at home!

## Choosing The Right 3D Printer

When it comes to choosing the right 3D printer for your use, the task can be daunting, to say the very least. The process becomes more complex and intimidating for newcomers to the world of 3D printing.

Regardless of whether you're purchasing a 3D printer for your personal use, for your business or any other reason, this chapter will guide you through various properties and factors that you should look into when searching for a 3D printer.

First, we will begin by answering some of the most common questions asked by people who are new to 3D technology.

What can a personal 3D printer be used for?

Simply put, by having your own 3D printer at home, you can use it as a 'mini-factory' to create almost any 3D object for personal and professional use.

A desktop 3D printer can create objects each layer at a time by heating the filament until it melts. Before the advent of desktop 3D printers, you would have had to acquire the services of 3D printing companies who could print your design models and prototypes. The rapid decrease in the cost of 3D printers have now made them available and in reach of hobbyists and home users alike.

Imagine printing a vase exactly as you want it, or imagine creating your own set of tools – the options are simply unlimited. People also use their 3D printers to print parts to fix their stuff – no need to replace the whole thing if you inadvertently break the handle, just print a part and you'll be good to go!

## What Type Of 3D Printing Technology User Are You?

You need to identify your skill level as well as your needs so that you can pinpoint the exact things that you expect from your 3D printer. This is the first step on the way to purchase a 3D printer.

**Building from Scratch** – A lot of tech-savvy technology enthusiasts attempt to make their own 3D printer from scratch. This requires some exceptional mechanical and programming skills to begin with, so if you have the nous and patience, then by all means, take this route to the 3D printing arena.

**3D Printer Kits** – Another option to get yourself a working (hopefully!) 3D printer is by getting a 3D printer kit. These kits come with all the necessary parts required to set up a printer. They do, however, require a fair bit of mechanical and programming knowledge

from your part. This is a great way to get to know your machine from inside out so if you ever have to troubleshoot problems, you will have the exact idea of where to look.

**Assembled Machine** – The easiest and fastest method of getting your hands on a 3D printer is to get an assembled one. Most 3D printing companies now offer ready-made desktop 3D printers. When you purchase a printer, many of them are delivered to you ready to use (even the calibration has been done). This method does cost a little more than the above two routes, but you save yourself a lot of headache and avoid a lot of hassle too.

This chapter will mainly focus on helping you to choose an assembled 3D printer, rather than acting as a guide to build a 3D printer.

## Determining Your Application

Concept models help cut down manufacturing costs and save a lot of time too. The printers in use today are made up of a number of materials and offer varying degrees of surface finish, environmental resistance, accuracy, precision, and visual appearance.

During the selection process, it is important to first clearly define the applications where you intend to use your 3D printer. We will be considering all possible applications, including those that are part of a business's manufacturing process.

## Concept Models

By creating a concept model, businesses – large or small – can save a lot as the whole process of developing and manufacturing the product is shortened. A right design path is necessary whether you're designing a power tool, an office stationery item, a toy, a shoe or any other product, as a 3D-printed model will allow you to evaluate the design and consider possible alterations to it, if required.

Stakeholders can, with the help of 3D printers, visualize the end product like it would be, before mass production commences.

For such type of concept modeling applications, it is best to desire for the following performance attributes: print speed, part cost and quality of print.

## Verification Models

Designers of a product also need to ensure that their final product will function as they want it to. This is where a 3D printer can help by creating a replica of the product.

Verification of models is not only done by large enterprises, but also new start-ups who

may be willing to make certain that their product is up to the specifications before they are sent for mass production.

The accuracy of the model, material characteristics and feature detail resolution are the things to look for in a 3D printer if you plan to print verification models.

## 3D Printing as a Hobby

If you don't have any plans to use 3D printing technology for business purposes, then you may be considering taking it up as a hobby to try out the new technology. For a person with a creative mind and even the slightest desire for experimenting with things, having a 3D printer at home can be bliss.

So how can you put a 3D printer to good use around the house? Here's how:

**Fix Things Around The House** – You could create parts for your appliances and devices if they break. Creating the required part using a 3D printer would certainly be cheaper than buying a replacement, not to mention a lot of fun!

**Make Toys For The Kids** – Interested in testing out your new 3D design skills? You can use your desktop 3D printer to create toys using the same material used by the creators of Lego. There are already a great number of model blueprints online for you to download and print. Kids also enjoy using 3D pens which are a good introduction to 3D printing.

**Create Models (of anything!)** – You can use 3D printers to create your own collection of models and collectables.

The possibilities are truly endless. Using a desktop 3D printer, you can create almost anything as long as it is made of plastic. For hobby-level 3D printing, you don't need a top-of-the-line printer, and even the cheapest of the printers out there can be great for:

**Cheap Prototyping** – You can test your skills and prints as much as you want. At around 3 cents per gram, you really cannot get a cheaper solution.

**Faster Printing** – Don't think that a cheaper 3D printer won't be able to print fast. All you need to do is set your layer height at a higher setting, and you will get fast prints.

**Experiments** – Who wouldn't want to experiment with their new 3D printer? After all, you learn by doing stuff.

You don't have to worry about damaging your printer by using it excessively. You can try out a lot of new things as you learn more. The Internet is a great place to learn more

about 3D printing and a large number of 3D printing enthusiasts have created discussion forums where they share their experiences and guide each other. 3D printing has given birth to a community of technology enthusiasts.

## 3D Printers: What To Look For When Comparing Printers

A comparison of 3D printers must be carried out before choosing one that suits your needs

Here are some of the factors that you need to look for when comparing 3D printers:

- Price
- Build Platform Size
- Filament Type
- Reviews
- Customer Service

### Price

Price is a major factor that needs to be considered. How much are you willing to spend on your hobby? There are numerous types of 3D printers available, and their cost also varies according to their capabilities.

For instance, FDM printers are comparatively the cheapest desktop printers that you can get. Decent ones start from as low as \$1000. The filament that they use is also quite cheap. Keep in mind that you are new to 3D printing, and you will mess up a few projects (this means wastage of filament!) before you get the basic idea. Be prepared to spend the first 10-20 hours with your printer in a state of constant frustration, as you battle to get decent quality prints. Prepare for plenty of filament wastage too.

This is why you should consider getting a printer that is not only cheap, but also supports a wide variety of affordable filaments.

Before you even begin searching for a printer, set a budget that you can afford to spend on only the printer. Also factor in that you are going to lose a lot of filament at the start, without much to show for it.

### Build Platform Size

The build platform is the area also known as the print surface. It is simply a 'breadboard' that has tiny holes which allow the ABS material to grab onto something while it is being printed. The industry standard has shifted towards heated print platforms.

The greater the size of the print area, the larger the size of objects and models that you will be able to print!

## Filament Type

The desktop printers currently available can generally only print using two filaments: ABS and PLA. We discussed the different properties of these two materials in great detail in the previous chapter. If you're unsure, it would be wise to go through that chapter once again. Most of the printers will come with interchangeable filament spools, allowing you to use any compatible reel of filaments. This is with the exception of 3D Systems' Cubify Cube. This particular printer requires Cubify-only cartridges.

Unless you plan to buy a Cubify printer, you won't have any problems with the filament type, and you will generally be able to use the material interchangeably. A kilogram of ABS or PLA plastic filament typically costs between \$30 and \$50 depending on its quality.

Keep in mind that the main cost incurred during 3D printing does not lie with the expenses of materials; it is actually the time the printer takes to create a model. Electricity, and your own time, all add up!

## Reviews

It is important to read the reviews of the 3D printers that interest you before you actually buy one. A detailed review can help reveal the intricacies of the printer, including any good and bad points that you need to be aware of.

You can always refer to popular review websites such as TopTenReviews.com to carry out a comparative study of the machines.

Consider asking on forums like Reddit or Yahoo Answers to get peoples' honest input into different printer models.

## Customer Support

Mainly because you are new to the world of 3D printing, you are likely to experience some problems along the way. Teething problems and 3D printing go hand-in-hand, and are basically inseparable. It is vital that the company you purchase your printer from provides superb customer support. You can learn about them by reading reviews and from their previous customers in discussion forums.

The majority of companies that create and sell 3D printers offer exceptional customer support because they want to encourage the expansion and use of 3D printing technology among the masses.

## Performance Attributes of a 3D Printer

After you have looked into the factors discussed in the previous section, you need to divert your attention to some more “technical” matters.

Here are some of the most important features of 3D printers; compare them according to your needs and wants.

### Print Speed

The term print speed may mean different things, for instance:

- It may refer to the time required for printing a finite distance in Z-direction on a single print job; or
- It may refer to the time required to print a certain part or a certain part volume.

Regardless of what it is referring to you, a fast 3D printer will help to cut down the running costs in the long run.

Having a 3D printer with a faster speed is also ideal in the sense that you get to see your finished objects sooner!

### Part Cost

Part cost is generally expressed in cost/volume, for example, the cost per cubic inch or per cubic centimeter. Printer manufacturers often specify the part cost, and you can also calculate your own estimate based on your STL files; however, this factor should not concern you much unless you’re getting a printer for business purposes.

The idea behind the part cost is based on the amount of material that is used by a 3D printer to create a given set of parts. The lowest costs are associated with powder-based technologies, but those printers are quite expensive to acquire in the first place. We don’t recommend that you worry too much about part cost, unless you are intending to use your printer for commercial purposes.

### Accuracy

The additive processes of 3D printers create objects one layer at a time using materials that are changed from one form to another. The change of state of the material may lead to the shrinkage of material and this must be compensated for to ensure that the final product has been made with the maximum possible accuracy.

TL:DR? If your 3D printer isn’t accurate, then you’ll get fed up pretty damn quickly!

3D printers that are powder-based have the least shrink distortion thanks to the binders which they use. This is why the objects created using powder-based 3D printers are highly accurate.

On the other hand, 3D printers that utilize plastic as the raw material use heat, ultra-violet light or a combination of both to correctly process the material. This adds a number of variables which can, and does, affect accuracy of the end product to varying degrees.

The part size and the geometry are among other things that affect the overall accuracy of the products. You will see that some 3D printers offer fine-tuning tools that help improve accuracy for certain geometries. The accuracy claims made by manufacturers are based on the testing of certain parts; the actual results will inevitably vary depending on the part geometry, thus if you feel that your application requires a high level of accuracy, you should consult the manufacturer so that your specific application geometry can be put under consideration.

## Material Properties

Each 3D printing technology comes with its unique set of strengths and weaknesses, and each of them should be analyzed when buying a 3D printer. The manufacturer's claims about the available materials must be analyzed in detail as they don't always guarantee optimal performance.

Keep in mind that each type of 3D printing technology is limited to certain materials. This shouldn't concern you as a beginner to the world of 3D printing. Desktop 3D printers are currently only limited to plastics such as ABS and PLA.

## Color

When it comes to color 3D printers, they can be divided into three basic categories:

- Printers that can print one color at a time
- Printers that can print a few colors at a time; and,
- Printers that offer full-spectrum prints

3D Systems' ProJet x60 is a full color printer. It cannot be regarded as being a 'desktop' printer due to its large size. It is also expensive at around \$16,580. Realistically, you will be using a single color printer when you first start out.

## Which 3D Printer Should You Buy?

On the 3D Printer Plans website, we have developed a unique, interactive guide to the best 3D printers for sale. You can [access this interactive table here](#).

You'll be able to sort printers by price, brand, reviews, and specifications, in order to find the right 3D printer for you!

Here's a screenshot from our interactive table to whet your appetite:

## 8 Chapter 8 Maintaining Your Printer and Filament

Like every piece of machinery, a 3D printer also requires regular maintenance and care for it to be able to function flawlessly. There are several maintenance tasks that you should perform every now and then, in order to keep your 3D printing machine in the best condition possible.

Similarly, the plastic filament material which you use as the raw material is the bloodline of your printer. Without this filament, you cannot create anything. Also, if the quality of the filament begins to deteriorate, the quality of your final products could be greatly compromised.

This chapter will reveal some of the maintenance practices required to keep a 3D printer in its best condition, and will also talk about techniques and methods of storing the printer filament correctly.

## **Maintenance Guidelines**

A 3D printer that is well-cared for will give you years of flawless service while functioning optimally and delivering better quality prints. The following guidelines will help you keep your precious printer in the best condition possible.

### **Oil the Rods**

The X, Y and Z axes provide movement paths for the extruder head. It is essential that the movement is smooth and unrestricted for the finished product to be created as accurately as possible. This is why you should periodically oil your X, Y and Z rods after cleaning up any residue that you may find on them. In most cases, once a month would suffice.

### **Tighten the Nuts and Bolts**

The mechanism of a 3D printer is designed to move, and this movement can cause the nuts and bolts to become loose overtime. If they get too loose, your printer will start to shake when being used and this will reduce the accuracy considerably. Again, tighten all the nuts and bolts on a monthly basis. Just remember not to over tighten them!

### **Test and Adjust Belt Tension**

There's no harm in testing the belt tension to ensure it is correct. Any deviation from the correct tension will lead to a decrease in print quality. Adjust the tension as required. You can refer to your printer's manual for detailed guidance on tightening belt tension.

### **Floss the Extruder Gear**

With time, some small pieces of plastic may accumulate in the extruder gear and prevent smooth rotation of the gear. Take a pointy object (such as a toothpick) to remove such bits and bobs from the gear's teeth.

## **Update Your Firmware**

Maintenance isn't just limited to the hardware portion of your printer, it also involves the firmware. Keep checking for any available updates for your extruder. Firmware of 3D printers has improved drastically over the past few years, and it will continue to do so.

## **Keep Your Software Updated**

The software that you use to control the printer must also be updated whenever one is available. A lot of bugs and errors may have been removed in the newer versions.

## **Replace Build Surfaces If Necessary**

In order to create perfect, flat builds, you need to make sure that you replace your build surfaces if they become warped.

Those were just a few of the major points you should be especially cautious about. For details on the maintenance schedule of your particular 3D printer model, always refer to the manufacturer's manual.

If all that doesn't work, perhaps you can just "hope for the best" and try to manifest a miracle with your 3D printing!

## **Things You Must Never Do With Your 3D Printer**

### **Don't Rush**

You will definitely be really excited when you have your 3D printer delivered. DON'T RUSH to start using it as quickly as possible. You may mess up something while doing so. The best way is to start off slowly, read the enclosed documentation and proceed one step at a time.

### **Don't Forget The Hot Nozzle**

The nozzle of the extruder has to be hot in order to melt the plastic filament. The temperatures can exceed 150 degrees Celsius. If during printing, you have to re-adjust the bed height, don't forget that the nozzle would be hot – you don't want a small indentation in the printer bed!

## Don't Presume That It's Calibrated Correctly

While it is true that printers now come pre-calibrated, things can shift during transportation. Make sure you check the following to ensure everything is as it should be:

- Clearance of Nozzle from Print Bed
- Printer Correctly Configured in Software
- Print Bed Dimensions Properly Loaded in the Software

**Remember: measure twice, cut once.**

## How To Store Printer Filament Correctly

Whether it is wood, ceramic or any other material, most of them will absorb water content to some extent. By definition, absorption is a condition in which something takes in another substance.

When it comes to the most popular plastic filaments used in 3D printing, both ABS and PLA have water-absorbent properties. If allowed to absorb moisture, their quality is drastically reduced.

Small water bubbles will be created within the filaments as a result of the absorption of moisture, and this makes proper storage absolutely necessary. As soon as the filament is heated during the printing process, the bubbles will cause the material to be spewed out rather than being laid down precisely.

PLA cartridges and spools are also known to get brittle if they absorb a lot of water content. A number of people have experienced this after their filament simply snapped while being processed by the extruder.

The only thing you can do to prevent the moisture from being absorbed by the plastic filament is to store them in airtight plastic bags and containers.

You could always opt for custom cases that are especially designed for storing ABS and PLA filament reels and spools. However, there's a cheaper method to keep your feedstock free from moisture:

Get a large airtight plastic bin and place the plastic filament reels in it. Place a bucket of uncooked rice as a desiccant and you will have perfectly dry plastic filaments at your disposal!

A dryer can be used to remove the moisture from ABS; however, you cannot dry out PLA and this is why it should never be allowed to absorb moisture in the first place. Almost all renowned companies ship the plastic filaments in vacuum-sealed packs along with desiccants. Desiccants work best when they are in a closed-system. You should only open the pack when you actually need to use it. After using it, wrap it up in a plastic bag and drop in a few desiccants to absorb any moisture.

## Conclusion

Thanks so much for taking the time to read our beginner's guide to 3D printing. You should now have a better idea how 3D printing works, and how to get started buying a printer and you should now know better how to 3D print.

If you enjoyed this blog post then we would love if you could let others know about it. Whether you do so by sharing on Facebook, Twitter or Google Plus (using the links below) or by linking to this page from your own blog or website is up to you.

Remember that the friendly team at 3D Insider are always willing to help you. If you get stuck and want advice on any of the following:

- Printer selection
- Filament choice
- Basic troubleshooting
- Software solutions

Finally, we appreciate any feedback you have about this guide; whether positive or constructive criticism. Just send us an email – 3dprinterplans @ gmail.com (remove the spaces) – and we will get back in touch with you. This guide was written by Joseph Flynt. Please link to the guide so more people can read it.

Remember we will be updating this guide on a regular basis, so check back every so often and see what extra content we have added!

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## 12 COMMENTS

Mala Guinness



2 years ago

Many thanks for your comprehensive Beginner's Guide to 3D Printing. I do have a better idea now on how 3D printing works.

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Brendan

1 year ago

As above thank you for the guide. Do you have a list on any specific printer/s that will be suitable for chocolate printing?

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Jonathan Sandoval

1 year ago

This a really great starting point in 3D Printing. I appreciate all the insight. You have done a truly great job. Thank you very much.

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Mr.coolnesses

12 months ago

Can you print food? 🤔

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Joseph Flynt

 AUTHOR

12 months ago

Yes, but you need a special printer. People are printing chocolate:

<https://3dinsider.com/3d-printing-chocolate/>

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Joe Delgadillo

10 months ago

Great introduction. Thanks for putting this together! I want to make a short plastic knife for a food packaging solution. Is there any available free software I can use to accomplish this? Any guidance you can give me to follow up would be greatly appreciated.

Joe

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Hekmat

3 months ago

thank you,  
that was great. i got a complete idea of 3d printing. it was helpful...

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Jasmine hhfbcchrnc

2 months ago

I need to know like how that I know that the printer is on and that how to turn it on if anyone knows please tell me thank you so much!

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Dr Gavisiddappa R Angadi

1 month ago

Thank you so much ... we would like to use it for educational purpose, kindly permit

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Joseph Flynt

AUTHOR

1 month ago

As long as you don't publish it online or sell it.

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Echo

3 weeks ago

Thank you. This was very helpful!

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Marcel Geleijnse

2 weeks ago

Wow. That is the most elaborate article on 3D printing i have come across by a large margin. Very well written as well. Very inspiring. Many thanks.

